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PREFACE

This presentation is the first annual report for P. L. 89-304, AFC 10 project "Anadromous Fisheries Research, Virginia," for the period 1 December 1980 to 30 November 1981. The fishes of concern were the alewife (Alosa pseudohargengus), American shad (A. sapidissima), and the blueback herring (A. aestivalis).

The following jobs were contracted by the Virginia Institute of Marine Science.

Job 1. Catch and Effort Statistics of the Virginia Alosa Fisheries

Objectives

1. Estimate fishing effort, landings, and catch-per-unit-of-effort (CPUE) of adult river herring (alewife and blueback herring) and American shad in Virginia during the 1981 fisheries.

2. Determine the present status of the stocks relative to former years by comparison of landings and CPUE.

Job 2. Population Dynamics of the Virginia Alosa Fisheries

Objectives

1. Estimate current vital statistics (age and size frequencies, species composition, mortality rates, etc.) of river herring and American shad.

2. Contrast current vital statistics to the existing Virginia data base for the Alosa fisheries.

Job 3. Annual Index of Juvenile Alosa Abundance

Objectives

1. Determine an index of abundance of juvenile river herring and American shad.

2. Study the growth and relative abundance of juveniles.

ACKNOWLEDGMENTS

We are indebted to the following Virginia Institute of Marine Science personnel for their assistance in this project: James Bristow, Roy Crabtree, Jacque Carter, Joice Davis, Deane Estes, Kevin Friedland, Marion Hennigar, Curtis Leigh, Tom Munroe, James Owens, Nancy Peters, and Gloria Rowe. Mr. Frank Wojcik contributed the juvenile Alosa length date of the VIMS winter trawl survey.

Potomac River catch data were supplied by Commissioner Robert M. Norris and his staff of the Potomac River Fisheries Commission.

The project was funded in part by the United States National Marine Fisheries Service, Northeast Region, through Public Law 89-304.

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SUMMARY

1. Stake gill nets in the James River yielded an estimated 0.1 million kg of American shad in 1981, a decrease of 71% relative to 1980.

2. The American shad catch-per-unit-of-effort (CPUE) for stake gill nets in the James River decreased from 9.6 kg/m in 1980 to 3.1 kg/m in 1981.

3. Pound nets in the York River landed an estimated 3,000 kg of American shad and 195,200 kg of river herring in 1981, a decrease of 69% for American shad and 11% for river herring relative to 1980.

4. Stake gill nets in the York River landed an estimated 182,400 kg of American shad, declining from 271,700 kg in 1980.

5. The CPUE for American shad landed from stake gill nets in the York River declined from 13.7 kg in 1980 to 8.6 kg in 1981.

6. Pound nets in the Rappahannock River landed an estimated 1,700 kg of American shad and 321,700 kg of river herring in 1981, an increase of 47% for river herring and no change for American shad relative to 1980.

7. Stake gill nets in the Rappahannock River caught an estimated 12,600 kg of American shad, an increase of 19% compared to 1980.

8. The CPUE for American shad landed in stake gill nets in the Rappahannock River decreased slightly from 1.2 kg in 1980 to 1.1 kg in 1981.

9. Pound nets in the Potomac River landed 800 kg of American shad and 36,200 kg of river herring in 1981, a decrease of 20% and 87%, respectively.

10. Gill nets in the Potomac River (stake, anchor and drift) yielded 1,100 kg of American shad in 1981.

INTRODUCTION

Stock assessment consists essentially of the collection and analysis of basic data such as catch, effort and development of an index (relative or absolute) of abundance of the fish stock under consideration (Gulland 1978). Estimates of total landings by gear type may be obtained from the product of catch-per-unit-of-effort (CPUE) and the total units of gear fished. Specific values of effort by gear type and CPUE in any particular year are not themselves of exceptional significance but rather it is the trend in the data from year to year that is important (Gulland 1978).

The CPUE and the estimated landings may be used as a relative indicator (index) of stock abundance by a simple comparison with such estimates in prior years, provided there are not large annual fluctuations in availability of the fish and the total units of gear fished remains relatively constant (Rounsefell 1975).

A unit of effort can be expressed as whole units, such as pound nets or haul seine, or as a part of the whole unit such as catch per linear meter of gill net. Crochet et al. (1976), Klauda et al. (1976), and Jones et al. (1976) expressed CPUE as catch per million ft of net per hr, catch per million yards of net per hr and catch per ft of net per hr, respectively. All authors used catch and/or CPUE as an estimate of relative abundance.

MATERIALS AND METHODS

The 1981 catch estimates of adult Alosa were computed by the method of Hoagman and Kriete (1975). Pound net catch estimates were

determined by multiplying the CPUE (kg/net/half-month) of the index nets by the number of nets actively fishing (weighted by net size) in each section of the river. Index nets are those for which daily records were kept by cooperating fishermen. Effort was determined by semi-monthly aerial counts of active pound nets (Table 1.1 and Fig. 1.1). Yearly pound net CPUE was determined by dividing total landings by the average number of nets fished.

Stake gill net catch estimates were determined by multiplying the CPUE (kg/m of net/half-month) of index nets by meters of stake gill netting in 5-nautical mile sections of the river (Hoagman and Kriete 1975). Effort was determined by a count of stake gill nets during the peak of the American shad fishing season (Table 1.2). Yearly stake gill net CPUE was determined by dividing total landings by total netting fished for shad.

Potomac River catch and effort data were supplied by the Potomac River Fisheries Commission.

RESULTS AND DISCUSSION

The 1981 fishing season for American shad began during the latter half of February for many Virginia gill net fishermen. Installation of many pound nets, the primary gear for river herring, was delayed until March or early April to avoid possible damage by ice. Low abundance combined with low market value does not warrant the risk of net loss or the expense of the additional labor to set the nets for river herring and American shad.

Most stake gill net fishermen began to remove their nets by mid-April because of declining catches as well as rapidly rising water temperature. Average ex-vessel prices for American shad declined in 1981 compared to 1980 (.28/lb vs .36/lb). The price per pound when adjusted by the consumer price index decreased more than .04/lb compared to 1980 (Table 1.3).

The total number of pound nets in 1981 peaked the first half of May at 279 nets, a slight increase compared to 1980 effort (272 nets) (Loesch and Kriete, 1980). The number of gill net stands in 1981, set primarily for American shad, remained unchanged from 1980 at 381 stands (Loesch and Kriete 1980), while total meters of gill netting decreased 9% during the same period (Table 1.2).

The 1981 estimated landings of American shad and river herring by pound nets declined relative to 1980 in all rivers reporting pound net catches except the Rappahannock River where landings of river herring increased (Table 1.4). Estimated landings of American shad by stake gill nets in 1981 decreased in all except the Rappahannock River where there was an increase compared to 1980.

Pound net CPUE declined for all Alosa species in all rivers surveyed except river herring and male American shad in the Rappahannock River which exhibited an increase compared to 1980 (Table 1.5). Stake gill net CPUE of American shad decreased in all rivers relative to 1980 except for the CPUE of males in the Rappahannock River which remained unchanged.

James River

No pound nets were set in the James River during January through June (Table 1.1). Records of fyke net landings in the James River showed a dramatic decrease in river herring landings in 1981 compared to 1980. Only 720 kg of river herring were landed during the period of 1 March through 30 April 1981. No American shad were reported landed by fyke nets in the James River during the same period.

Stake gill nets in the James River caught an estimated 0.1 million kg of American shad during the 1981 shad fishing season (Table 1.6), a 71% decrease relative to 1980 (Table 1.4). Peak landings for both sexes occurred during the first half of April 1981 (Table 1.6). Many of the fishermen felt that much of the decline in catch was attributed to fouling of the nets. Large amounts of "grass" (bryozoans) were caught in the nets necessitating long drying periods to clear the nets for fishing.

York River

Pound nets in the York River caught an estimated 3,000 kg of American shad and 195,200 kg of river herring in the 1981 spring fishing season (Table 1.7). This represented a 69% decrease in landings of American shad and a decrease of 11% for river herring compared to 1980 (Table 1.4).

Males dominated the landings, contributing 87% of the American shad landed by pound nets. By contrast, females constituted 74% of the American shad landed in 1980 (Table 1.4).

Alewife landings in 1981 declined 87% relative to 1980 while blueback exhibited a modest gain (Table 1.4).

The CPUE for American shad (male and female combined) by pound nets continued to decline, dropping from 2,485 kg in 1978, to 214 kg in 1981 (Table 1.5). During the same period the CPUE for river herring continued to increase, rising from 12,665 kg in 1978 to 18,362 kg in 1980; however, CPUE for river herring declined to 13,945 kg in 1981.

Peak landings of American shad and river herring in pound nets occurred during the latter half of April and the first half of May, respectively (Table 1.7). The bulk of the fish landed were "down run" or fish that had already spawned and were proceeding downriver toward the ocean.

Stake gill net effort continued to increase in 1981 relative to 1980, reversing the trend which began in 1975 (Table 1.5). However, estimated landings declined from 271,700 kg in 1980 to 182,400 kg in 1981 (Table 1.4). Peak landings in 1981 for males occurred during the second half of February and during the second half of March for females (Table 1.8).

Rappahannock River

Pound nets in the Rappahannock River yielded an estimated 1,700 kg of American shad and 321,700 kg of river herring during the 1981 spring fishing season (Table 1.9). This represents a 47% increase for river herring compared to 1980 while American shad

remained virtually unchanged. Peak landings of river herring occurred during the second half of April in the nets above mile 30 and the first half of May for the nets below mile 30. As in the York River the bulk of the river herring landed in May were "down-runners" or fish that had spawned and were returning to sea.

The CPUE for American shad by pound nets in the Rappahannock River continued to decline in 1981 relative to 1980 while the CPUE for river herring increased 39% during the same period (Table 1.5).

Stake gill nets landed an estimated 12,600 kg of American shad in 1981 (Table 1.10) an increase of 24% compared to 1980 (Table 1.4). This increase may be due, in part, to an increase of 32% in effort, reversing the decline in effort begun in 1977 (Table 1.5).

Although landings of American shad by gill nets increased in 1981, CPUE declined slightly (Table 1.5) owing to the increase in effort.

Potomac River

Pound nets in the Potomac River landed 800 kg of American shad and 36,200 kg of river herring during March through June 1981 (Table 1.11), a decline of 20% and 87%, respectively, relative to 1980 (Table 1.4). The possible causes of the dramatic decline of river herring are unknown. Due to budgetary constraints we were unable to sample the Potomac River. Peak landings in 1981 occurred in April for both American shad and river herring.

The 1981 CPUE data for the Potomac River were based on data from March through June to be comparable with previous years. The CPUE for American shad by pound nets continued to decline, decreasing 25% from 20 kg in 1980 to 15 kg in 1981 (Table 1.5). Similarly the CPUE for river herring declined from 5,569 kg in 1980 to 710 kg in 1981.

Gill nets (anchor and stake combined) in the Potomac River landed 1,100 kg of American shad in 1981, a decrease of 5,400 kg compared to 1980 (Loesch and Kriete 1980). Stocks of shad are low and effort by gill netters has been redirected to striped bass which are more abundant and command a higher ex-vessel price; thus, reduced effort contributed to the decline in landings. Peak landings of females occurred in March for Virginia fishermen but did not occur until April for Maryland gill netters (Table 1.11).

Data are not available from the Potomac River Fisheries Commission to derive CPUE for American shad.

Catch-Effort Evaluation

Stocks of Alosa fishes in Virginia have been declining since the late 1960's (Loesch and Kriete 1976, Loesch et al. 1979), although data from individual rivers may not consistently reflect this continuing decline from year to year.

Estimated landings of American shad by pound nets in the York River continued the decline begun in 1978 (Table 1.4). Landings of American shad in the Rappahannock River, although low, remained stable, while Potomac River landings continued to decline. Estimated

landings of river herring by pound nets in the York and Rappahannock rivers declined in 1981, reversing a trend begun in 1978. As mentioned above the cause of the notable decline in landings of river herring in the Potomac River is unknown. However, there was a 22% decline in the number of pound nets in May in 1981 relative to 1980. Also, the peak number of nets in 1981 did not occur until the second half of June as opposed to the first half of May in 1980, the month that the bulk of river herring were landed (Loesch and Kriete 1980).

Yearly CPUE of American shad by pound nets declined in all rivers in 1981 relative to 1980 (Table 1.5). Pound nets in the York River continued to have the highest CPUE for river herring in 1981, due in part to increased effort.

The 1981 estimated landings of American shad by gill nets declined in all rivers except the Rappahannock River which exhibited a modest gain (Table 1.4).

The CPUE of American shad by stake gill nets declined in all rivers in 1981 relative to 1980. The decline in CPUE in the Rappahannock River as opposed to the increase in landings is possibly due to an increase in effort. The Potomac River Fisheries Commission no longer reports stake and anchor gill net catches separately, therefore no CPUE was determined for that river.

LITERATURE CITED

Crochet, D. W., D. W. Allen and M. L. Hornberger. 1976. Evaluation of commercial fisheries for American shad in South Carolina and status of the species in selected waters. Proc. Workshop on American Shad. U.S. Fish. Wildl. Serv. and Natl. Mar. Fish. Serv., Amherst MA, p. 4.

Gulland, J. A. 1978. Assessment of a fishery. Pp. 274-288 in Methods for Assessment of Fish Production in Fresh Waters. T. Bagenal (ed.). Blackwell Scientific Publications, Oxford, London, Edinburgh, Melbourne. p. 365.

Hoagman, W. J. and W. H. Kriete, Jr. 1975. Biology and management of river herring and shad in Virginia. Annu. Rep. Virginia AFC 8-2. Virginia Institute of Marine Science, Gloucester Point, VA. 105 pp.

Jones, R. A., P. Minta, and V. Crecco. 1976. A review of American shad studies in the Connecticut River. Proc. Workshop on American shad. U.S. Fish Wildl. Serv. and Natl. Mar. Fish. Serv., Amherst, MA, p. 135.

Klauda, R. J., M. Nittel, and K. P. Campbell. 1976. The commercial fishery for American shad in the Hudson River: Fishing effort and stock abundance trends. Proc. Workshop on American shad. U.S. Fish Wildl. Serv. and Natl. Mar. Fish. Serv., Amherst, MA, p. 107.

Loesch, J. G. and W. H. Kriete, Jr. 1976. Biology and management of river herring and shad in Virginia. Completion Rep. 1974-1976. Virginia AFC 8-1 to 8-3. Virginia Institute of Marine Science, Gloucester Point, VA, pp. 1-36.

Loesch, J. G., and W. H. Kriete, Jr. 1980. Anadromous Fisheries Research, Virginia. Virginia Institute of Marine Science, School of Marine Science, College of William and Mary, Gloucester Point, VA, 96 pp.

Loesch, J. G., W. H. Kriete, Jr., J. G. Travelstead, E. J. Foell and M. A. Hennigar. 1979. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Completion Rep. NC-VA AFCS 9-1 to 9-3. Part II: Virginia Institute of Marine Science, Gloucester Point, VA, 204 pp.

Rounsefell, G. A. 1975. Ecology, utilization, and management of marine fishes. The C.V. Mosby Co., Saint Louis, p. 244.

Table 1.1. Number of active pound net stands in Chesapeake Bay and its Virginia tributaries during January-June, 1981.

	Area	Jan 26	Feb 25	Mar 18	April 10	April 23	May 14	May 29	June 11	June 22
A	James R.									
B	Back R.			3	6	6	5	4	2	1
C	Poquoson R.			1	1	1	1	1	1	0
D	York R.			2	6	18	20	17	16	17
E	Mobjack Bay				6	11	7	9	9	8
F	Piankatank R.			2	2	3	4	4	3	3
G	Rappahannock R.			25	47	48	50	35	35	29
H	Great Wicomico R.				3	5	5	6	7	7
I	Potomac R.			9	37	48	65	67	70	75
	a. Virginia Tributaries to Potomac R.						5	7	7	7
J	Cape Henry to Fort Wool			2	6	6	8	8	7	7
K	Old Point to Tue Marsh Point			3	10	10	11	5	9	10
L	York Spit				4	6	14	14	10	10
M	New Point to Stingray Point			4	13	16	23	24	23	23
N	Windmill Point to Smith Point			4	30	32	39	39	45	45
	Eastern Shore									
O	Above Hungar Creek									
P	Below Hungar Creek	5	5	3	7	14	22	23	26	31
	Total	5	5	58	178	224	279	263	270	273

Table 1.2. Number of stake gill net stands fished in Virginia rivers 1979-1981 (A) and linear meters of gill netting fished primarily for American shad per five mile block (B) in 1981. Figures in parentheses represent the total meters of gill netting in the York and Rappahannock rivers.

A.

River	Number of Gill Net Stands 1979	1980	1981
James	168	179	142
York	117	147	147
Rappahannock	155	122	98

B.

River	Mile	Number of Stands	Number of Sections	Average Length/Section	Meters of Net	
James	05-10	31	855	10		8,550
	10-15	4	66	10		660
	15-20	64	1,059	15		15,885
	20-25	16	283	15		4,245
	25-60	27	594	15		8,910
	Total	142	2,857			38,250
York	05-10	6	114	11		1,254
	10-15	39*	635	11		6,985
	15-20	35*	544	11		5,984
	20-25	35*	533	7	(3,731)	3,541
	25-29	32	532	7	(3,724)	3,534
	Total	147	2,358		(21,678)	21,298
Rappahannock	15-20	1	10	18	(180)	144
	20-25	2	44	18	(792)	635
	25-30	25*	436	18	(7,848)	6,294
	30-35	16	313	18	(5,634)	4,518
	35-70	54*	861	13	(11,193)	
	Total	98	1,664		(25,647)	11,591

*Includes anchor gill net converted to stands.

Table 1.3. Dock-side value and adjusted value of American shad landings in Virginia for the years of 1967-1981. Pounds and value in thousands.

Year	Pounds	Value	Consumer Price Index	Adjusted Value	Adjusted Price/lb. (¢)
1967	2138	181	1	181.0	8.46
1968	2550	161	1.04	154.8	6.07
1969	2248	166	1.10	150.9	6.71
1970	4112	315	1.16	271.6	6.60
1971	1520	135	1.21	111.6	7.34
1972	2057	225	1.25	180.0	8.75
1973	2436	366	1.33	275.2	11.30
1974	1569	230	1.48	155.4	9.90
1975	1136	308	1.61	191.3	16.84
1976	896	284	1.70	167.0	18.64
1977	1468	498	1.81	275.1	18.74
1978	1234	211	2.03	103.9	8.42
1979	994	235	2.17	108.3	10.89
1980	973	353	2.47	142.9	14.68
1981(a)	499	141	2.72	51.4	10.30

(a) January-August 1981.

Table 1.4. Yearly landings in kg of American shad by pound nets and stake gill nets and river herring by pount nets. Landings for the James, York and Rappahannock rivers are estimations. Landings for the Potomac River are reported by the Potomac River Fisheries Commission.

	Stake Gill Net		Pound Net			
	American Shad		American Shad		River Herring	
	♂	♀	♂	♀	Alewife	Blueback
James						
1977	11,612	186,495	[			]
1978	116,348	574,935				
1979	17,328	263,203		(a)		
1980	59,003	343,026				
1981	12,056	105,550	[			]
York						
1977	3,376	137,748	8,894	3,217	10,298	87,966
1978	31,666	174,780	16,676	13,141	16,021	135,954
1979	23,460	186,074	5,492	10,224	22,256	195,150
1980	25,012	246,719	2,267	6,453	43,391	176,955
1981	23,453	158,905	2,361	630	5,454	189,769
Rappahannock						
1977	2,298	22,053	2,949	1,268	84,688	209,163
1978	10,909	45,870	2,096	1,871	130,804	381,734
1979	2,199	21,619	2,046	1,562	56,016	423,633
1980	1,366	8,831	614	1,038	23,283	195,354
1981	2,621	10,015	824	832	33,767	287,963
Potomac (stake, anchor and drift gill net combined)						
1977	2,704	29,708	3,775	2,458	34,671	179,961
1978	2,858	20,544	1,853	1,674	48,942	610,469
1979	900	9,492	1,134	649	11,516	437,152
1980	1,474	5,058	647	342	34,006	249,977
1981[b]	110	992	584	210	2,561	35,097

(a) Data not available.

(b) March through June data only.

Table 1.5. Yearly catch-per-unit-of-effort for American shad and river herring 1975-1981 in kg by species for stake gill net and pound net. Stake gill net effort in meters. Pound net effort in number of nets.

		Stake Gill Net			Pound Net				
			American shad			American shad		River Herring	
	Year	Effort	♂	♀	Effort	♂	♀	Alewife	Blueback
James River	1975	25,832	2.7	8.8	[				]
	1976	20,464	1.9	25.1					
	1977	26,884	0.4	6.9					
	1978	28,134	4.1	20.4			(a)		
	1979	37,207	0.5	7.1					
	1980	41,739	1.4	8.2					
	1981	38,250	0.3	2.8	]				
York River	1975	22,106	0.5	4.5	[				
	1976	21,424	0.3	3.0			(a)		]
	1977	19,326	0.2	7.1	10	889	322	1,030	8,797
	1978	15,954	2.0	10.9	12	1,390	1,095	1,335	11,330
	1979	13,968	1.7	13.3	12	458	852	1,855	16,262
	1980	19,940	1.3	12.4	12	189	538	3,616	14,746
	1981	21,298	1.1	7.5	14	169	45	390	13,555
Rappahannock River	1975	28,973	0.1	0.8	30	42	60	2,408	5,732
	1976	32,517	0.1	0.5	25	33	55	1,754	2,716
	1977	13,595	0.2	1.6	45	65	28	1,882	4,648
	1978	13,681	0.8	3.4	42	50	45	3,114	9,089
	1979	13,497	0.2	1.6	37	55	42	1,514	11,449
	1980	8,758	0.2	1.0	32	19	32	728	6,105
	1981	11,591	0.2	0.9	38	22	22	889	7,578
Potomac River	1975	76,553	0.1	0.5	23	149	43	16,625	89,071
	1976	78,858	<0.1	0.3	32	208	83	4,430	13,502
	1977	75,017	<0.1	0.3	51	74	48	680	3,529
	1978	56,839	<0.1	0.2	45	41	37	1,088	13,566
	1979	[			55	21	12	209	7,948
	1980(b)	(a)			51	13	7	667	4,902
	1981	]			53	11	4	48	662

(a) Data not available.

(b) March through June data only.

Table 1.6. Estimated catch in kg of American shad by stake gill nets for 5-mile sections in the James River 1981 by half-month intervals and by sex. Effort from Table 1.2. Index in kg/m of net.

Half-Month Period	River Mile	American Shad				Total Estimated Catch
		Male		Female		
		Index	Estimated Catch	Index	Estimated Catch	
February 2nd	05-10	0.0602	515	0.0946	809	1,324
	10-15		40		62	102
	15-20		345		785	1,130
	20-25	0.0217	92	0.0494	210	302
	25-60		193		440	633
	Total		1,185		2,306	3,491
March 1st	05-10	0.2281	1,950	0.6088	5,205	7,155
	10-15		151		402	553
	15-20		1,304		5,048	6,352
	20-25	0.0821	349	0.3178	1,349	1,698
	25-60		732		2,832	3,564
	Total		4,486		14,836	19,322
March 2nd	05-10	0.1351	1,155	1.3341	11,407	12,562
	10-15		89		881	970
	15-20		1,479		10,490	11,969
	20-25	0.0931	395	0.6604	2,803	3,198
	25-60		830		5,884	6,714
	Total		3,948		31,465	35,413
April 1st	05-10	0.0586	501	1.4778	12,635	13,136
	10-15		39		975	1,014
	15-20		316		15,682	15,998
	20-25	0.0199	84	0.9872	4,191	4,275
	25-60		177		8,796	8,973
	Total		1,117		42,279	43,396
April 2nd	05-10	0.0285	244	0.5843	4,996	5,240
	10-15		19		386	405
	15-20		578		5,077	5,655
	20-25	0.0364	155	0.3196	1,357	1,512
	25-60		324		2,848	3,172
	Total		1,320		14,664	15,984
Total by Sex			12,056		105,550	
Grand Total						117,606

Table 1.7. Estimated catch in kg of American shad and river herring by pound nets in the York River 1981 by half-month intervals. Figures in parentheses are estimated species composition.

Half-Month Period	Number Nets	American Shad				River Herring						Number of Index Nets
		Male		Female				Alewife		Blueback		
		Index	Estimated Total	Index	Estimated Total	Index	Estimated Total	Percent	Estimated Total	Percent	Estimated Total	
April 1st	5	53.2	319	52.0	312	226.8	1,361	16	218	84	1,143	6
April 2nd	18	56.3	1,013	16.1	290	3,217.9	57,922	2	1,158	98	56,764	10
May 1st	20	163.7	327	1.4	28	5,996.3	119,926	3	3,598	97	116,328	10
May 2nd	17	41.3	702	(a)		942.0	16,014	(3)	480	(97)	15,534	12
Total			2,361		630				5,454		189,769	
			2,991				195,223					

(a) None reported by index fishermen.

Table 1.8. Estimated catch in kg of American shad by stake gill nets for 5-mile sections in the York River 1981 by half-month intervals. Effort from Table 1.2. Index in kg/m of net.

Half-Month Period	River Mile	American Shad				Total Estimated Catch
		Male		Female		
		Index	Estimated Catch	Index	Estimated Catch	
February 2nd	05-10		532		897	1,429
	10-15	0.4246	2,966	0.7157	4,999	7,965
	15-20		2,541		4,283	6,824
	20-25	0.7337	2,598	1.0811	3,828	6,426
	25-29		2,593		3,821	6,414
	Total		11,230		17,828	29,058
March 1st	05-10		285		1,639	1,924
	10-15	0.2275	1,589	1.3069	9,129	10,718
	15-20		1,361		7,820	9,181
	20-25	0.4622	1,637	1.7875	6,330	7,967
	25-29		1,633		6,317	7,950
	Total		6,505		31,235	37,740
March 2nd	05-10		134		2,310	2,444
	10-15	0.1068	746	1.8424	12,869	13,615
	15-20		639		11,025	11,664
	20-25	0.3653	1,294	3.0703	10,872	12,166
	25-29		1,291		10,850	12,141
	Total		4,104		47,926	52,030
April 1st	05-10		58		1,672	1,730
	10-15	0.0466	326	1.3332	9,312	9,638
	15-20		279		7,978	8,257
	20-25	0.0930	329	3.8694	13,702	14,031
	25-29		329		13,674	14,003
	Total		1,321		46,338	47,659
April 2nd	05-10		13		412	425
	10-15	0.0102	71	0.3286	2,295	2,366
	15-20		61		1,966	2,027
	20-25	0.0210	74	1.5414	5,458	5,532
	25-29		74		5,447	5,521
	Total		293		15,578	15,871
Total by Sex			23,453		158,905	
Grand Total						182,358

Table 1.9. Estimated catch in kg of American shad and river herring by pound nets in the Rappahannock River 1981 by half-month intervals. Figures in parentheses are estimated species composition.

Half-Month Period	Mile	Number Nets	American Shad				River Herring						Number of Index Nets
			Male		Female				Alewife		Blueback		
			Index	Estimated Total	Index	Estimated Total	Index	Estimated Total	Percent	Estimated Total	Percent	Estimated Total	
March 1st	0-30		(a)		(a)		(a)						
	31-70	10	4.7	47	1.0	10	75.7	757	(71)	537	(29)	220	10
March 2nd	0-30	7	(a)		(a)		(a)						
	31-70	18	14.6	263	5.7	103	38.1	686	(44)	302	(56)	384	14
April 1st	0-30	26	(a)		(a)		3,095.0	80,470	18	14,485	82	65,985	5
	31-70	21	17.4	365	27.7	582	73.7	1,548	(33)	511	(67)	1,037	15
April 2nd	0-30	26	(a)		(a)		2,870.3	74,628	18	13,433	82	61,195	6
	31-70	22	2.7	59	5.9	130	310.1	6,822	(17)	1,160	(83)	5,662	15
May 1st	0-30	27	(a)		(a)		5,686.0	153,522	2	3,070	98	150,452	6
	31-70	23	3.6	83	0.3	7	128.6	2,958	(9)	266	(91)	2,692	13
May 2nd	0-30	25	(a)		(a)		(a)						
	31-70	10	0.7	7	(a)		33.9	339	(1)	3	(99)	336	9
Total				824		832				33,767		287,963	
				1,656				321,730					

(a) None reported by index fishermen.

Table 1.10. Estimated catch in kg of American shad by stake gill nets in the Rappahannock River 1981 by half-month intervals. Effort from Table 1.2. Index in kg/m of net.

Half-Month Period	River Mile	American Shad				Total Estimated Catch
		Male		Female		
		Index	Estimated Catch	Index	Estimated Catch	
February 1st	15-20	0.0192	3	0.0334	5	8
	20-25		12		21	33
	25-30		121		210	331
	30-35		87		151	238
	35-70(a)					
	Total		223		387	610
February 2nd	15-20	0.0159	2	0.0115	2	4
	20-25		10		7	17
	25-30		100		72	172
	30-35		72		52	124
	35-70(a)					
	Total		184		133	317
March 1st	15-20	0.0565	8	0.0725	10	18
	20-25		36		46	82
	25-30		356		456	812
	30-35		255		328	583
	35-70(a)					
	Total		655		840	1,495
March 2nd	15-20	0.0867	12	0.2142	31	43
	20-25		55		136	191
	25-30		546		1,348	1,894
	30-35		392		968	1,360
	35-70(a)					
	Total		1,005		2,483	3,488
April 1st	15-20	0.0178	3	0.3086	44	47
	20-25		11		196	207
	25-30		112		1,942	2,054
	30-35		80		1,394	1,474
	35-70(a)					
	Total		206		3,576	3,782
April 2nd	15-20	0.0300	4	0.2240	32	36
	20-25		19		142	161
	25-30		189		1,410	1,599
	30-35		136		1,012	1,148
	35-70(a)					
	Total		348		2,596	2,944
Total by sex			2,621		10,015	
Grand total						12,636

(a) None reported by index fishermen.

Table 1.11. Total catch in kg of Alosa fishes by gill nets (A) and pound nets (B) in the Potomac River 1981.

	American Shad					River Herring			
	Virginia		Maryland			Virginia	Maryland		
	Female	Male	Female	Male	Total				Total
A. Anchor and Stake Gill Net									
January			4		4				
February		1	10		11	20	5		25
March	812	21	14	31	878	756	141		897
April	38	40	107	16	201	723	244		967
May	7			1	8	3	4		7
Subtotal	857	62	135	48	1,102	1,502	394		1,896
B. Pound Net									
March	10	6	3	6	25	631	395		1,026
April	136	137	14	16	303	14,905	4,492		19,397
May	41	202	2		245	12,785	828		13,613
June	4	217			221	1,751			1,751
July									
August							468		468
Subtotal	191	562	19	22	794	30,072	6,183		36,255
Total	1,048	624	154	70		31,574	6,577		
Grand Total					1,896				38,151
						Alewife[1]	Blueback[1]	Alewife[1]	Blueback[1]
						2,147	29,427	447	6,130

[1]Estimated species ratio in commercial landings

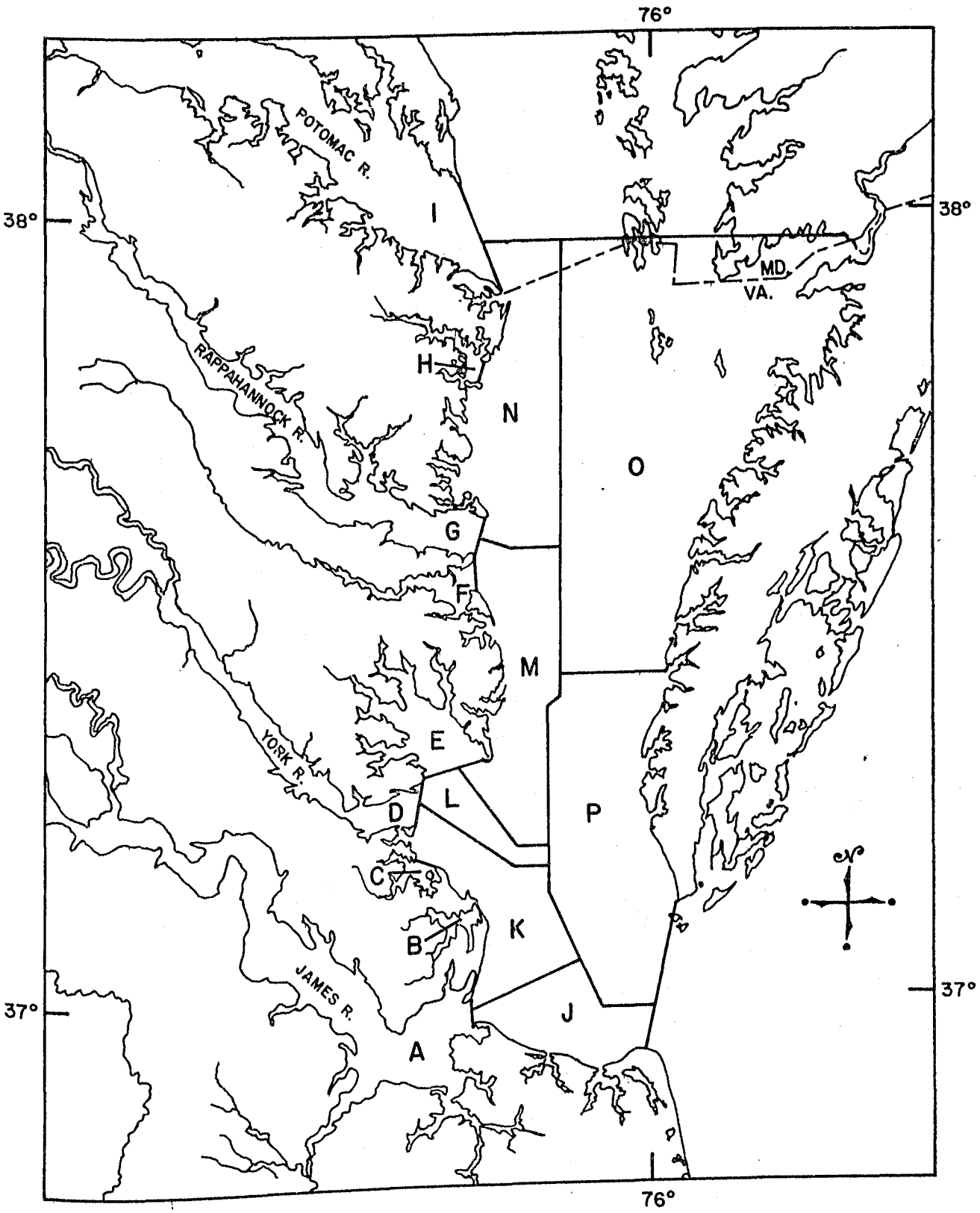


Figure 1.1. Area designations utilized during aerial pound net counts.

Job 2. Population Dynamics of the Virginia Alosa Fishery

SUMMARY

1. The 1981 river herring (alewives and blueback herring) landings in Virginia of 236 metric tons (MT) was the lowest catch recorded in the last 16 years. Catch-per-unit-of-effort data indicated that the decline reflected a reduced availability of blueback herring in 1981, although they still dominated the river herring composition.

2. Age structure, length and weight, and sex ratio determinations were made. The findings were compared with those for previous years, and were used to estimate year-class contributions to total landings for river herring.

3. Preliminary estimates of the instantaneous total mortality rate (Z) were made. The mean Z for alewives and blueback herring was 2.13 and 2.02.

Job 2. Population Dynamics of the Virginia Alosa Fishery

INTRODUCTION

The Virginia Institute of Marine Science (VIMS) continued its annual assessment of the structure of adult Alosa populations in Virginia inshore waters. These data are essential for any consideration of an Alosa management plan.

MATERIALS AND METHODS

Samples of river herring were collected once each in the month of April and May from the York and Rappahannock river fisheries. American shad samples were collected in April from the James, York, and Rappahannock fisheries.

When available 90.7 kg of river herring were randomly sampled from commercial pound net or fyke net catches. These nets employ a 50.8 mm stretched mesh in their entrapment section, and are assumed to be nonselective for river herring age 3 or older.

Random samples of up to 100 American shad were taken from commercial catches. The fishery primarily employs gill nets with mesh sizes (12.4-14.0 cm) which favor the capture of females, the larger of the sexes.

River herring samples were returned to VIMS where they were sorted by species and sex, body length and weight recorded, and scales and otoliths removed from random subsamples. American shad data were collected at the sampling site, except for age and spawning frequency

data which were derived from laboratory analysis of scales. Ages of river herring were determined from otoliths and American shad age from scales by the method of Cating (1953), i.e., counting the number of annuli and spawning check marks, and adding a year for the scale edge.

Domestic Alosa landings data for the years 1966-1972 were obtained from the respective U.S. Fishery Statistical Digests. The 1973-1976 data were from the annual summaries of Current Fisheries Statistics, NMFS, Division of Statistics and Market News. Subsequent landings data have been obtained from the Virginia Marine Resources Commission. Offshore foreign landings data were obtained from the respective ICNAF Statistical Bulletins.

A computer "package program", SPSS (Nie et al. 1975), was used to construct Tables 2.3 through 2.6 and Fig. 2.1.

RESULTS AND DISCUSSION

Sampling Effort

A total of 174 alewives, 1,994 blueback herring and 265 American shad were samples (Table 2.1). The number of river herring collected in the last three years was considerably less than in previous years. The reduction in sampling was, in part, due to monetary considerations, and, in part, due to a savings in time, effort and experimental units by the use of otoliths. Very few otoliths were unreadable. In contrast, large samples were needed in past years to obtain a relatively small proportion of usable scales due to their

loss or damage during spawning and, also, due to the handling in the pound net fishery.

Landings

The 1981 river herring landings in Virginia of 236 metric tons (MT) were only 44% of the 1980 landings (537 MT), and were the lowest catch recorded in the last 16 years (Table 2.2). Catch-per-unit-of-effort (CPUE) data in 1980 reflected a reduced blueback herring stock (Loesch and Kriete 1980). The 1981 CPUE data (Job 1, Table 1.5) indicate a large decline in alewife landings and CPUE for the York River fishery; similarly, these statistics dramatically decreased for both river herring species in the Potomac River fishery. River herring landings and CPUE increased in the Rappahannock River, but the gain was not sufficient to affect the decline in the other two river systems.

The 1981 decline in river herring landings in Viriginia continued the general decline that started in 1970 (Fig. 2.1), and is attributed to poor recruitment (Loesch et al. 1977) and heavy exploitation of river herring by the foreign offshore fishery in the late 1960's and early 1970's (Hoagman et al. 1973). River herring recruitment and foreign exploitation were previously discussed in detail (Loesch et al. 1979).

American shad landings in Virginia, like those of the river herring, have also declined since about 1970 (Fig. 2.1). The 1981 harvest of 226 MT was only 51% of the 1980 landings, and was the lowest harvest of record.

Age Composition

The age frequency of river herring (sexes pooled) by river by species determined from samples of the commercial fisheries catches in 1981 is presented in Tables 2.3-2.6. Mean and modal age data for the years 1977-1981 are summarized in Table 2.7. The mean and modal ages of river herring for the last three years has ranged between ages 4 and 5, a decrease from ages 5 and 6 in 1977 and 1978 (Table 2.7). The river herring age composition data were used in conjunction with sex ratio and mean weight-at-age data to estimate cohort contributions to the total landings in 1981.

American shad age frequency data by river for 1981 are summarized in Table 2.8 and age frequencies for all rivers for the years 1977-1980 are summarized in Table 2.9. The selection for females by the gill nets used in the American shad fishery, and the practice of discarding males at the net when their market price is low is indicated by the disparity between the members of males and females in our samples (Table 2.8 and 2.9). Loesch and Kriete (1980) reported that age frequency for American shad in the fishery was not independent of years. The significance was due to a shift from an age 5 mode in 1977 to ages 6 in 1978 and 1979 and then back to age 5 (males) and ages 5-6 (females) in 1980. Changes in the American shad mean and modal ages tended to parallel the river herring age changes. Since all three Alosa species have overlapping spawning seasons and all are tidal-freshwater and estuarine-dependent during most of their

first-year of development, similar year-class success could be expected.

A chi-square contingency test indicated that the year-class frequency of female American shad (Table 2.8) was not independent of the sources of the samples ($P<0.0001$). The significance was due to the greater proportion of females $\leq$ age 5 in the Rappahannock River samples, and, conversely, the greater proportion of females $\geq$ age 6 in the James and York river samples. The reason(s) for the difference in year-class structure is not known. Log book records indicate that gill nets with 127 mm stretched mesh are primarily used in the Rappahannock River, while 123.8 mm stretched mesh is preferred in the oter two systems; thus, a selection of smaller fish in the Rappahannock River is not a factor. Also, all samples came from stake gill nets, except for four females taken in anchor gill nets in the Rappahannock River. The anchor gill employed the same mesh size as the stake gill nets, 127 mm. Additionally, since all American shad samples were collected between 7-10 April the differences cannot be attributed to a change in ages structure during the fishing season.

For the pooled data the mean and modal ages of female American shad in 1981 were essentially the same values as in 1980 (Table 2.9). However, chi-square analysis also indicated that these statistics were derived from significantly different age distribution ($P<0.0001$). Ages 3-10 were represented in the 1981 samples, but only ages 4-8 were present in the 1980 samples. The mean and modal ages of males decreased in 1981 (Table 2.9), but the data are few ($N = 13$).

Length and Weight Analysis

Mean values for fork length and total body weight (Table 2.10) indicated a tendency for the alewife values to decrease and those for the blueback herring to increase relative to the 1980 findings (Loesch and Kriete 1980). The changes are considered more apparent than real. Mean and modal ages were near constant in 1980 and 1981, and the observed differences between annual estimates of mean lengths and mean weights were not consistent. For example, the mean length and mean weight differences for alewife males and females in the York River samples were not significant (P ranged from >0.05 to >0.40); in contrast, the same statistics derived from the Rappahannock River samples of alewives were significant ($P<0.001$ for all four analyses). The difference between the annual mean lengths of male blueback herring in the York River examples was significant ($P<0.05$), but the mean weight difference was not ($P>0.50$). In contrast, the annual mean length difference for male blueback herring was not significant ($P>0.50$), but the mean weight difference was significant ($P<0.05$) when derived from the samples collected from the Rappahannock River fishery.

The most pertinent use of these data, specifically mean weight-at-age, in conjunction with age composition and sex ratio data, was to estimate year-class contributions to the total landings in 1981.

The mean length and weight of female American shad (Table 2.11) in the James and Rappahannock rivers were not significantly different,

but did differ from the mean length and weight derived from samples collected in the York River (Table 2.12). As was the case for the differences in age structure in the fisheries, no rationale can be offered at this time for the observed size differences.

Sex Ratio

Chi square (χ^2) analysis of the homogeneity of sex ratios among the river specific samples was not significant (Table 2.13) for both alewives ($P>0.80$) blueback herring ($P>0.10$). For the pooled data, the analysis of a hypothesized 1:1 sex ratio was rejected for alewives ($P<0.001$) and blueback herring ($P<0.01$). The high level of significance associated with female alewife predominance may be the result of a later commencement of the river herring fishery in 1981. Historically, the pound net river herring fishery in Virginia has begun in March but in 1981, it did not start until April. Cooper (1961) and Kissil (1974) reported that the number of alewife males was superior to the number of females in the first part of the spawning season; an equal number of both sexes, or a predominance of females, occurred later in the spawning season.

The sex ratio data were used in conjunction with age structure and mean weight-at-age data to estimate year-class contributions to the total landings in 1981.

Species Composition

Blueback herring constituted 81% of the river herring sampled in 1979 and 1980 (Loesch and Kriete 1980). There has been a significant

increase in the proportion of blueback herring relative to alewives since 1974 (Loesch et al. 1979); thus, as the Virginia river herring stock has declined since the early 1970's, the rate of decline for alewives has been greater than the rate for blueback herring. Several conjectural explanations for this change were offered by Loesch and Kriete (1980). In 1981, only 8% of the river herring sampled were alewives. The apparent further decrease in the proportion of alewives is believed to be due to the absence of samples in March, a time when alewives are generally much more abundant than blueback herring.

Species composition data were used to partition the total landings into the species-specific components.

Cohort Mortality Estimates

The annual and total cohort (year-class) contributions in metric tons to the Potomac and Rappahannock alewife and blueback herring fisheries from 1968-1980 were estimated by Loesch and Kriete (1980; their Tables 2.21 - 2.24). Their annual Potomac catch and effort statistics were derived from a weighted analysis of monthly landings and the mean of semimonthly observations of effort; however, similar statistics obtained from the Rappahannock River fishery were unweighted. A weighted analysis of the Rappahannock river herring data has now been completed for the years 1973 through 1980, and is continuing. Also, the catch and effort data, by species, have now been pooled for the river herring fisheries in the Potomac and Rappahannock rivers. This was done because the relative cohort contributions to the catch follow similar trends in both rivers, and

there is no evidence to support a concept of separate stocks. Another adjustment made to the cohort data presented by Loesch and Kriete (1980) was to lower the observed age structure in the years 1976, 1977 and 1978. It was suspected that there was a change in the method of reading scales in 1976 that resulted in an additional year of age. During the period of preparation of this report a workshop for aging shad and river herring was held by the ASMFC Shad and River Herring Scientific and Statistical Committee in Charleston, S.C., on 1-2 February 1983. All members attending the workshop aged the fish one year younger than the previous determination. Adjustment of the age structure removed the apparent anomaly of having a cohort's biomass and CPUE increase, or remain relatively high, at an age when the year class should contribute little to the landings. The change to otoliths in 1979 eliminated the consideration of an ambiguous scale mark that was called an annuli in the years 1976, 1977, and 1978.

Estimations of the instantaneous total mortality rate (Z) were obtained from catch curves, i.e., the regression of $\log_e$ CPUE on cohort age. Ideally, the resulting lines should have been linear; however, inflections sometimes occurred which indicated incomplete recruitment of age 4 fish and/or a sharp decline in ages $\geq$ 7. River herring mortality for the 1972 and 1973 year classes sharply increased relative to the three previous year classes (Table 2.14). Eighty percent of the alewife mortality values exceed those for the blueback herring when year classes are paired; the percentage difference is significant ($P<0.05$), but the data, at present, are few.

LITERATURE CITED

Cating, J. P. 1953. Determining age of Atlantic shad from their scales. U.S. Fish and Wildl. Serv. Fish. Bull. 54(85):187-199.

Cooper, R. 1961. Early life history of the alewife, Alosa pseudoharengus. M.S. Thesis. Univ. of Rhode Island, Kingston. 58 p.

Hoagman, W. J., J. V. Merriner, R. St. Pierre, and W. L. Wilson. 1973. Biology and management of river herring and shad in Virginia. Comp. Rep. 1970-1973. Nat. Mar. Fish. Serv. Proj. No. AFC 7-1 to 7-3. Virginia Institute of Marine Science, Gloucester Point, Virginia. 210 p.

Kissil, G. 1974. Spawning of the anadromous alewife, Alosa pseudoharengus, in Bride Lake, Connecticut. Trans. Amer. Fish. Soc. 103(2):312-317.

Loesch, J. G., W. H. Kriete, Jr., H. B. Johnson, B. F. Holland, Jr., S. G. Keefe, M. W. Street. 1977. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Annu. Rep. 1977. Nat. Mar. Fish. Serv. Proj. No. AFCS-9-1. Virginia Institute of Marine Science, Gloucester Point, Virginia, and North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries, Morehead City, North Carolina. 183 p.

Loesch, J. G., W. H. Kriete, Jr., J. G. Travelstead, E. J. Foell, and M. A. Hennigar. 1979. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Part II: Virginia. Comp. Rep. 1977-1979. Nat. Mar. Fish. Serv. Proj. No. AFCS 9-1 to 9-3. Virginia Institute of Marine Science, Gloucester Point, Virginia. 204 p.

Loesch, J. G. and W. H. Kriete, Jr. 1980. Anadromous fisheries research program, Virginia. Annu. Rep. 1980. Nat. Mar. Fish. Serv. Proj. No. AFC 10-1. Virginia Institute of Marine Science, Gloucester Point, Virginia. 96 p.

Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. Statistical package for the social sciences. McGraw-Hill Book Co., New York. 675 p.

Table 2.1. Summary of sample data from the Alosa commercial fisheries during the 1981 spawning run in the major Virginia tributaries to Chesapeake Bay.

River and Month	ALEWIFE		BLUEBACK		AMERICAN SHAD	
	Male	Female	Male	Female	Male	Female
James						
April					8	61
York						
April	27	49	383	407	5	95
May	6	7	198	217		
Rappahannock						
April	26	50	169	171	4	92
May	4	5	189	260		
Totals (M&F)	174		1994		265	

Table 2.2. River herring catches in the North Carolina and Virginia inshore fisheries and the foreign offshore fishery in ICNAF Area 6.

Year	Catch (metric tons*)		
	North Carolina	Virginia	Foreign
1966	5,677	12,941	
1967	8,383	12,746	981
1968	7,040	14,657	1,075
1969	8,962	13,807	10,474
1970	5,225	8,637	6,052
1971	5,769	4,664	9,442
1972	5,096	4,740	4,974
1973	3,594	4,203	2,452
1974	2,816	6,050	2,817
1975	2,699	5,152	1,341
1976	2,903	1,839	1,554
1977	3,855	630	
1978	2,996	965	
1979	2,322	766	
1980	2,820	537	
1981	2,043	236	

*MT - 2,205 lb.

Table 2.3. Year-class frequency of alewives (sexes pooled) in the York River commercial fishery samples, 1981.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	73.	1	1.1	1.6	1.6
	74.	2	2.2	3.2	4.8
	75.	7	7.9	11.3	16.1
	76.	23	25.8	37.1	53.2
	77.	26	29.2	41.9	95.2
	78.	3	3.4	4.8	100.0
	9.	27	30.3	MISSING	100.0
	TOTAL	89	100.0	100.0	

MEAN	76.290	STD ERR	0.123	MEDIAN	76.413
MODE	77.000	STD DEV	0.965	VARIANCE	0.931
KURTOSIS	1.525	SKEWNESS	-0.961	RANGE	5.000
MINIMUM	73.000	MAXIMUM	78.000		
VALID CASES	62	MISSING CASES	27		

Table 2.4. Year-class frequency of blueback herring (sexes pooled) in the York River commercial fishery samples, 1981.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	71.	1	0.1	0.3	0.3
	72.	1	0.1	0.3	0.6
	73.	2	0.2	0.6	1.2
	74.	15	1.2	4.4	5.5
	75.	100	8.3	29.2	34.7
	76.	87	7.2	25.4	60.1
	77.	133	11.0	38.8	98.8
	78.	4	0.3	1.2	100.0
	9.	862	71.5	MISSING	100.0
	TOTAL	1205	100.0	100.0	

MEAN	75.988	STD ERR	0.056	MEDIAN	76.103
MODE	77.000	STD DEV	1.037	VARIANCE	1.076
KURTOSIS	1.000	SKEWNESS	-0.751	RANGE	7.000
MINIMUM	71.000	MAXIMUM	78.000		
VALID CASES	343	MISSING CASES	862		

Table 2.5. Year-class frequency of alewives (sexes pooled) in the Rappahannock River commercial fishery samples, 1981.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	74.	1	1.2	1.5	1.5
	75.	7	8.2	10.6	12.1
	76.	12	14.1	18.2	30.3
	77.	38	44.7	57.6	87.9
	78.	8	9.4	12.1	100.0
	9.	19	22.4	MISSING	100.0
	TOTAL	85	100.0	100.0	

MEAN	76.682	STD ERR	0.108	MEDIAN	76.842
MODE	77.000	STD DEV	0.880	VARIANCE	0.774
KURTOSIS	0.654	SKEWNESS	-0.858	RANGE	4.000
MINIMUM	74.000	MAXIMUM	78.000		
VALID CASES	66	MISSING CASES	19		

Table 2.6. Year-class frequency of blueback herring (sexes pooled) in the Rappahannock River commercial fishery samples, 1981.

CATEGORY LABEL	AGE CODE	ABSOLUTE FREQ	RELATIVE FREQ (PCT)	ADJUSTED FREQ (PCT)	CUM FREQ (PCT)
	71.	1	0.1	0.3	0.3
	72.	1	0.1	0.3	0.5
	73.	8	1.0	2.1	2.6
	74.	17	2.2	4.5	7.1
	75.	92	11.7	24.3	31.4
	76.	43	5.4	11.3	42.7
	77.	215	27.2	56.7	99.5
	78.	2	0.3	0.5	100.0
	9.	410	52.0	MISSING	100.0
	TOTAL	789	100.0	100.0	

MEAN	76.158	STD ERR	0.058	MEDIAN	76.628
MODE	77.000	STD DEV	1.134	VARIANCE	1.287
KURTOSIS	0.981	SKEWNESS	-1.156	RANGE	7.000
MINIMUM	71.000	MAXIMUM	78.000		
VALID CASES	379	MISSING CASES	410		

Table 2.7. Summary of mean and modal ( ) age data for river herring in the Virginia commercial fishery, 1977-1981.

Species	Year	River				
		James	Pamunkey	York	Rappahannock	Potomac
Alewife	1977	5.4 (5)	5.7 (5-6)	5.2 (5)	5.6 (5-6)	5.5 (5-6)
	1978	5.5 (5-6)	5.6 (5-6)	5.4 (5-6)	5.6 (5-6)	5.6 (5-6)
	1979	4.0 (4)	[	4.1 (4)	4.0 (4)	4.4 (4-5)
	1980	4.7 (4-5)	(b)	4.6 (4-5)	4.5 (4)	4.4 (4)
	1981	(a)	]	4.7 (4-5)	4.3 (4)	(a)
Blueback	1977	5.7 (6)	6.0 (6)	5.8 (6)	5.8 (6)	6.0 (6)
	1978	6.3 (6)	5.6 (5-6)	5.8 (6)	6.0 (6)	6.1 (6)
	1979	4.8 (4)	[	4.5 (4)	4.5 (4)	4.3 (4)
	1980	5.0 (5)	(b)	4.7 (5)	5.0 (5)	5.0 (5)
	1981	(a)	]	5.0 (4)	4.8 (4)	(a)

(a) Not sampled.

(b) No river herring fishery.

Table 2.8. Year-class frequency of American shad in the Virginia commercial fishery, 1981.

Sex	Year Class	James	York	Rapp.	Total	Frequency (%)
Male	1974	1			1	7.7
	1975			1	1	7.7
	1976	1	2	1	4	30.8
	1977	1	3	2	6	46.1
	1978	1			1	7.7
	Total	4	5	4	13	
Female	1971		1		1	0.4
	1972	1	3	1	5	2.2
	1973		7		7	3.0
	1974	10	12	3	25	10.8
	1975	26	40	12	78	33.8
	1976	13	23	35	71	30.7
	1977	8	8	27	43	18.6
	1978			1	1	0.4
	Total	58	94	79	231	

Chi-Square Analysis

H_o: Year-class frequency is independent of the rivers sampled.

$\chi^2 = 56.2$; $P < 0.0001$

Table 2.9. Age frequencies of American shad in pooled samples from the Virginia commercial fishery, 1977-1981.

Sex	Year	AGE 3	4	5	6	7	8	9	10	Total Number	Mean Age	Modal Age
Male	1977		46	58	17	5	2			128	4.9	4-5
	1978		3	68	102	13	1			187	5.6	6
	1979		7	25	53	9	1			95	5.7	6
	1980		11	69	38	6	2			126	5.3	5
	1981	1	6	4	1	1				13	4.6	4-5
Female	1977		53	433	190	15	2			693	5.2	5
	1978		4	138	389	42				573	5.8	6
	1979		6	75	179	56	5			321	5.9	6
	1980		11	178	195	44	6			434	5.7	5-6
	1981	1	43	71	78	25	7	5	1	231	5.5	5-6

Table 2.10. Length (mm) and weight (g) statistics for river herring in the York and Rappahannock rivers, 1981.

			YORK			RAPPAHANNOCK		
Species	Sex		N	Mean	Std Error	N	Mean	Std Error
Alewife	Male	Length	33	246.9	2.463	30	236.8	4.541
		Weight	33	184.5	4.827	30	189.2	7.314
	Female	Length	56	262.5	1.773	55	250.9	1.823
		Weight	56	223.2	5.272	55	218.1	5.501
Blueback	Male	Length	581	249.3	0.459	357	247.5	0.553
		Weight	581	189.7	1.267	357	194.4	1.725
	Female	Length	623	261.5	0.430	431	258.2	0.548
		Weight	622	223.9	1.463	431	223.7	1.998

Table 2.11. Length (mm) and weight (g) statistics for American shad in the James, York and Rappahannock rivers, 1981.

Sex		JAMES N	JAMES Mean	JAMES Std Error	YORK N	YORK Mean	YORK Std Error	RAPPAHANNOCK N	RAPPAHANNOCK Mean	RAPPAHANNOCK Std Error
Male	Length	8	435.7	10.928	5	410.5	6.782	4	437.0	15.478
	Weight	8	1303.2	51.977	5	1008.5	39.573	4	1302.0	73.072
Female	Length	61	463.0	2.166	95	454.5	2.148	92	467.8	2.170
	Weight	61	1756.3	33.708	95	1619.0	26.946	92	1796.6	26.594

Table 2.12. Summation of analysis of variance and the Student-Newman-Keuls analyses of female American shad length and weight data from the James, York and Rappahannock rivers. (see Table 2.11).

Source of variation	df	Mean square	F	P
Length	2	4,202.39	10.52	<0.0001
Residual	245	399.14		
Total	247			
	SNK grouping of mean lengths:		$\underline{\bar{L}_1\ \bar{L}_2}\ \bar{L}_3$*	
Weight	2	793,961.38	11.74	<0.0001
Residual	245	67,604.45		
Total	247			
	SNK grouping of mean weights:		$\underline{\bar{W}_1\ \bar{W}_2}\ \bar{W}_3$*	

*Subscript index: Rappahannock (1); James (2); York (3).
Underscoring indicate no significant difference.

Table 2.13. Chi square (χ^2) analysis of river herring sex ratios in the York and Rappahannock rivers, 1981.

Species	River	Male	Female	Total
Alewife	York	33	56	89
	Rappahannock	30	55	85
	Total	63	111	174

H_o: Sex ratio was independent of rivers.
$\chi^2 = 0.06$; $P>0.80$

H_o: Sex ratio is 1:1 for the pooled data.
$\chi^2 = 12.6$; $P<0.001$

Species	River	Male	Female	Total
Blueback herring	York	581	622	1203
	Rappahannock	357	431	788
	Total	938	1053	1991

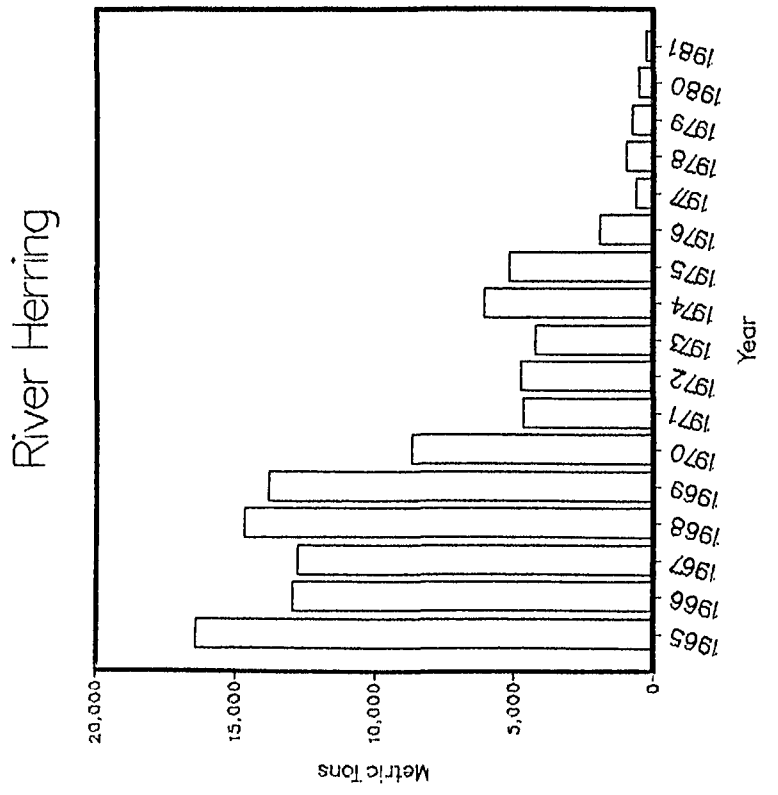
H_o: Sex ratio was independent of rivers.
$\chi^2 = 1.71$; $P>0.19$

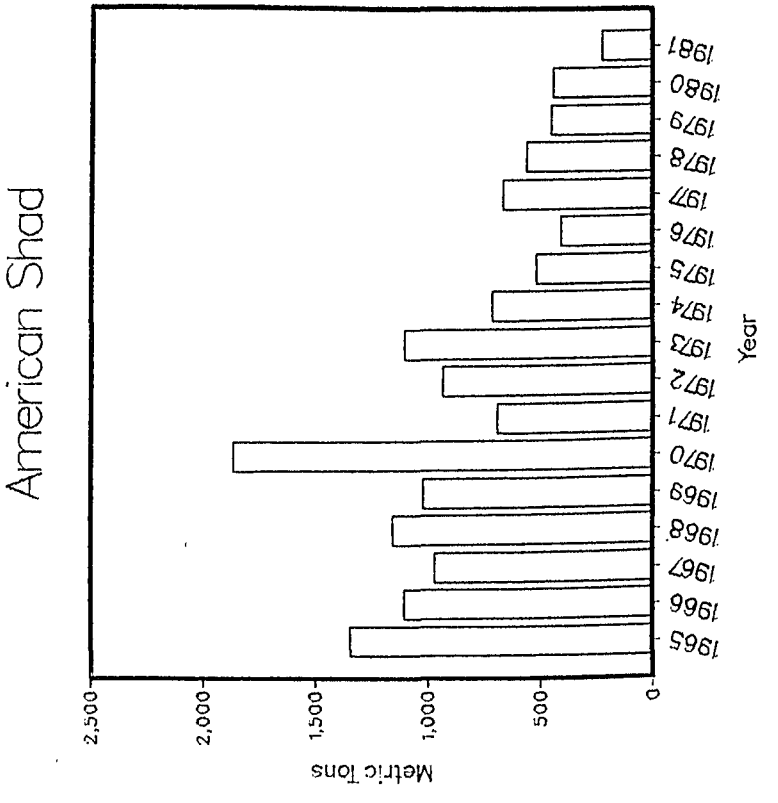
H_o: Sex ratio is 1:1 for the pooled data.
$\chi^2 = 6.52$; $P<0.01$

Table 2.14. Estimates of the instantaneous total mortality rate (Z) for the 1969-1973 cohorts of river herring.

Yearclass	Z values	
	Alewife	Blueback herring
1969	1.72	1.96
1970	1.49	1.26
1971	1.89	1.59
1972	3.35	3.26
1973	3.09	2.03
Mean	2.13	2.02

Figure 2.1. Virginia Landings 1965–1981





Job 3. Annual Index of Juvenile Alosa Abundance

SUMMARY

1. The juvenile Alosa index of abundance used was the largest average catch-per-unit-of-effort value obtained in replicate samples; herein, it is referred to as the maximal CPUE.

2. Juvenile blueback herring were chosen as an "indicator species" since commercial landings of alewives, American shad and blueback herring have exhibited parallel trends.

3. In general, maximal CPUE decreased from 1979 to 1981. However, a necessary reduction in effort in 1980 and 1981 resulted in the failure to consistently precede the maximal CPUE with a lower mean CPUE. Thus, higher index values could possibly have been obtained in 1980 and 1981. Future sampling will concentrate all effort in the York River system, thereby allowing an early starting date, and weekly sampling until the maximal CPUE is determined for all three Alosa species.

4. The observed growth is considered minimal because of juvenile recruitment and a suspected downstream drift of larger individuals. The mean fork lengths of alewives and blueback herring captured in a trawl survey from December 1981 through February 1982 were 89.7 mm and 78.5 mm, respectively.

5. Based on declines in CPUE data the estimated daily instantaneous mortality rates are 0.04 and 0.05 for river herring and American shad, respectively.

Job 3. Annual Index of Juvenile Alosa Abundance

INTRODUCTION

Immediate objectives were to determine relative abundance, growth, and mortality of juvenile, migratory Alosa. Long-term objectives are to determine if there is a relationship between the annual index of abundance and future recruitment, and to determine if there is a periodicity of strong year classes.

MATERIALS AND METHODS

Past annual indices of juvenile (young-of-the-year) Alosa until 1977 were derived from a single, daytime, trawl survey in (at least) the James, Chickahominy, Pamunkey, Mattaponi, Rappahannock and Potomac rivers. That sampling scheme implied that the proportion of juvenile stock available to the gear at the time of sampling was constant year to year, and fish availability was independent of light intensity. However, Loesch et al. (1982) reported diel migratory activities by juvenile anadromous Alosa, and an association between sky-opacity index values and surface catches of blueback herring. Their findings suggest that the juveniles (or their prey) are negatively phototropic. Kriete and Loesch (1980), additionally, reported that a bow-mounted pushnet greatly enhanced the catchability of juvenile Alosa relative to the surface trawls previously used. Based on these findings, nighttime sampling commenced in 1978, using both surface trawls and the pushnet. Catch data were adjusted to a constant volume of water filtered, determined from net opening and distance traveled. In 1979,

flow meters were installed in the pushnet and trawls for more precise estimates of the volume of water filtered in standard 5-min samples. The pushnet was used exclusively for sampling juvenile abundance. The trawls and pushnet were used in a comparison study of gear efficiency in order to adjust existing trawl catch data to equivalent pushnet values. Another major change in 1979 was that the frequency of sampling in each river was increased from one to six periods between June and October. The basic sampling scheme in 1979 was a stratified random sampling plan with allocation of effort a function of stratum surface area. Details of the sampling plan were presented by Loesch et al. (1979); the scheme was repeated in 1980 and 1981, but differed in sampling frequency and intensity. In 1980, six rivers were sampled three times, once each in July, August and September. The Potomac and Chickahominy rivers were omitted in 1981 and the remaining four rivers were sampled four times between early July and mid-September.

With the institution of multiple periods of sampling, the juvenile index of abundance was redefined as the maximal mean CPUE. This value was derived by averaging the CPUE's of the strata in a sampling period after weighting each stratum CPUE by its respective effort (ergo, the equivalent of the mean of all sample elements). The maximal CPUE was chosen as an index, in preference to a seasonal mean CPUE, for two major reasons. First, a general downstream drift of the larger juveniles in the fall, ahead of the mass migration associated with decreasing river temperatures, has been reported for blueback herring and American shad (Loesch 1969, Marcy 1976). Thus, emigration affects late-season availability in the nursery zones. Second, if

gear avoidance increases with size, the effect is minimized with maximal CPUE since it occurs relatively early in the total period of juvenile availability in the nursery zones. Another major factor was the variation in the duration of sampling seasons because of economic considerations. A seasonal CPUE for the juvenile Alosa would decrease the more protracted the sampling season.

Estimates of mean CPUE that followed the maximal CPUE, but clearly preceded the onset of the seaward migration, were used in conjunction with the maximal value to estimate the instantaneous natural mortality rate (M). The $\log_e$ of the ratio of maximal CPUE to a subsequent CPUE was used to calculate M when there was only one usable CPUE subsequent to the maximal value. Division by the number of days elapsed from the maximal CPUE (day 1) to the subsequent CPUE gave the daily instantaneous rate of natural mortality (M_d). With two or more usable CPUE values following the maximal CPUE, catch curves (Ricker 1975) were used to derive M_d.

Increases in mean fork length were used to calculate juvenile Alosa growth. The range in length of a species in a given sampling period is rather restricted and preliminary analysis of blueback herring data by strata indicated that a standard error equal to 5% of the mean length could be obtained with a random subsample of about five fish (Loesch and Kriete 1980). Arbitrarily, 15 fish per stratum (as available) were randomly selected in 1980. In 1981 all juvenile Alosa in samples of size $\leq$ 50 were measured; larger catches were randomly subsampled.

RESULTS AND DISCUSSION

Relative Abundance

Juvenile Alosa mean CPUE data by strata for each of the four rivers sampled in 1981 are presented in Tables 3.1-3.4. Catch statistics for 1979 and 1980, by river by strata, were presented by Loesch and Kriete (1980). Maximal CPUE data by river, for the years 1979, 1980 and 1981 are presented in Tables 3.5-3.7.

Based on the 1979 findings, Loesch et al. (1979) concluded: (1) blueback herring CPUE greatly exceeded those for alewives and American shad; (2) blueback herring CPUE reached a maximum in July or early August then declined. In contrast, alewife and American shad CPUE were generally greatest in June or early July; and (3) juveniles were more widely distributed in June and early July, had greater upriver concentrations in the summer, and then moved downriver in September and October as a first stage of their seaward migration. The superiority of the blueback herring CPUE is probably, in part, due to differences in Alosa phototropic behavior (Loesch et al. 1982); however, commercial landings indicate that blueback herring are more abundant than alewives (Loesch et al. 1979). Differences in the time of maximal CPUE stem from the differences in time when the bulk of each species spawns. Changes in the distribution of the juveniles probably reflect hydrological changes; apparently, juveniles move upriver in the summer because of the lessening of freshwater runoff and the ensuing encroachment of saline water.

Patterns of juvenile Alosa relative abundance were repeated in 1979, 1980 and 1981. Alewife indices were largest for the Rappahannock River, with the York River system's indices a distant second in each year (Table 3.5). The alewife indices were relatively low in the Potomac River, and few or no juvenile alewives were captured in the other systems sampled. American shad indices in all three years were highest in the York River system, but few or no juveniles were captured in the other rivers (Table 3.6). The blueback herring was the dominant juvenile Alosa species captured each year, except in the Mattaponi River where the juvenile American shad was most abundant (see Tables 3.1-3.12 in Loesch and Kriete 1980; Tables 3.1-3.4 herein). Also, in all three years, maximal CPUE for blueback herring occurred in the Rappahannock River (Table 3.7).

In general, the juvenile indices for blueback herring and the indices for alewife and American shad in the systems of their greatest abundance (the Rappahannock and York rivers, respectively,) show a decrease from 1979 to 1981. We are reserving comment at this time, because the trend could result from a reduction in sampling effort. In 1979, the juveniles were sampled six times in each river (Loesch and Kriete 1980). With the exception of the Potomac River, where the second sampling period was one week later than in the other rivers, the maximal CPUE for blueback herring was bracketed by smaller mean CPUE values. The commencement of the 1979 juvenile sampling between 20-26 June, however, was too late to bracket the maximal CPUE for alewives and American shad; thus, larger indices possibly could have been obtained with an earlier starting period. Subsequent to 1979, it

was necessary to reduce sampling effort. Since commercial landings of American shad and river herring exhibit parallel trends, the more frequently caught blueback herring was chosen as an "indicator species" for estimates of juvenile relative abundance. Based on the time of blueback herring maximal CPUE in 1979, sampling commenced in early July in 1980 and 1981. The result of this strategy was that maximal CPUE coincided with the first sampling period in all rivers in 1980, and in 50% of the rivers sampled in 1981. The weakness of this strategy is very apparent; it assumes a relatively limited period in which maximal CPUE occurs, and that any difference that could occur between the observed maximal CPUE and a higher value is nonsignificant. (Because of the need to reduce effort, and the failure to consistently bracket the maximal CPUE for blueback herring in 1980 and 1981, a change will be made in the 1982 sampling scheme.) All effort will be concentrated in the Mattaponi and Pamunkey rivers. Sampling will commence in June and each river will be sampled weekly until a cursory examination of the catches indicates that the maximal CPUE is bracketed for all three Alosa species.

Growth

Growth curves constructed from the 1979 juvenile fork length data were presented by Loesch and Kriete (1980). They cautioned that two aspects of these curves must be interpreted from the life history of the Alosa. During the season, there is a tendency for the larger juveniles to migrate downstream (Loesch 1969, Marcy 1976). Thus, growth will be underestimated if these individuals leave the nursery

zone. The other aspect of Alosa behavior that affects estimates of juvenile growth (and mortality) is their protracted spawning period. Juveniles collected in June through early August in the Virginia nursery zones are primarily products of the early spawners. About mid-August, the juveniles produced by the bulk of the spawners become susceptible to capture by the pushnet. The result of this recruitment was an apparent decrease in the growth rate, or an observed decrease in mean length (Loesch and Kriete 1980). This apparent "negative growth" was noted for juvenile blueback herring in the Susquehanna River (Whitney 1961) and in the Connecticut River (Loesch 1969); it is also apparent in the juvenile American shad growth curve presented by Marcy (1976; his Fig. 46).

In 1981, the estimates of mean fork length of juvenile Alosa between late July-early August and late August, as in 1979 and 1980, exhibited a decrease in the growth rate (Figs. 3.1, 3.2 and 3.3). The observed growth must be considered a minimum because of the effects of recruitment and emigration. Loesch and Kriete (1980) reported that the slower growth and higher natural mortality of blueback herring in the Chickahominy River may be more apparent than real. The Chickahominy River has a small nursery zone, about 27 km, and emigrants would soon enter the James River. The downstream drift of the larger juveniles would result in an underestimate of growth and are overestimate of mortality. The Chickahominy River, upstream of Walker's Dam, is used as a water source by the City of Newport News. There are no data that would indicate environmental problems in the river that could account for the lowest observed growth rates, or a

daily instantaneous mortality rate for blueback herring that is double (or more) that estimated in the other river systems (Loesch and Kriete 1980). Conversely, the relatively slow decline in CPUE in the James River between July and August in 1979 and 1980 (Loesch and Kriete 1980), and again in 1981 (Table 3.1) could be the result of blueback herring emigration from the Appomattox and Chickahominy rivers and the large Jones Neck and Turkey Island oxbows.

The mean length estimates in early July 1981, when the problems of recruitment and emigration should have had the least effect, indicate that: 1) juvenile blueback herring, on the average, were largest in the James River and smallest in the Mattaponi River; intermediate mean sizes in descending order, occurred in the Rappahannock and Pamunkey rivers, 2) alewife mean length was greatest in the Rappahannock River, intermediate in the Pamunkey River, and smallest in the Mattaponi River; and 3) American shad were larger in the Pamunkey River than in the Mattaponi River. These findings are in agreement with data previously presented by Loesch and Kriete (1980). The Mattaponi River is the clearest of the rivers sampled; this condition could reflect a limiting food supply which is responsible for the smaller observed mean juvenile fork lengths.

Estimates of instantaneous growth rates have not been made at this time because of the unknown confounding effects of juvenile recruitment and emigration.

A VIMS daytime, bottom trawl survey in the James, York and Rappahannock rivers from December 1981 through February 1982 captured

80 juvenile alewives and 159 blueback herring. For the pooled data, the mean fork lengths (and standard errors) were 89.7 mm (0.8262) and 78.5 mm (0.5043) for alewives and blueback herring, respectively. It is not known if these values are valid statistics for the bulk of the juvenile river herring which migrated to sea.

Natural Mortality

Estimates of daily instantaneous mortality rates (M_d) for the three juvenile Alosa species were made in 1979, 1980, and 1981 (Table 3.8). In 1979, because of the greater frequency of sampling periods, and a shorter time lapse between the periods, most estimates of M_d were made from catch curves (Loesch and Kriete 1980). However, in 1980 and 1981, because of reduced effort and the large time lapses between sampling periods, and the inflation of estimates of CPUE due to juvenile recruitment in mid-August, the $\log_e$ ratio of maximal CPUE to the succeeding CPUE, and subsequent division by the elapsed time in days, was used to estimate M_d.

In general, there was an increase in the M_d for juvenile alewife and American shad, and a decrease for the blueback herring M_d in 1980 and 1981, relative to the 1979 estimates. The trends may be more apparent than real, a result of the late commencement of sampling and the relatively large time interval between successive samples. The alewife and American shad spawn earlier, and have a shorter spawning season than the blueback herring. A significant downstream drift of the larger juvenile alewives and American shad between the sampling periods in early July and early August would inflate the estimates of

M_d. Conversely, recruitment of the later spawned blueback herring would inflate the estimates of CPUE in early August and produce underestimates of M_d. The explanations are, of course, speculations, but their veracity may be evaluated from weekly CPUE data in the Mattaponi and Pamunkey rivers in 1982 and 1983.

We conclude, at present, from the 1979 estimates, that the mean M_d and the actual daily survival rate (S_d) for juvenile river herring (excluding data from the Chickahominy River) and American shad are 0.04 and 0.05, and 0.96 and 0.95, respectively.

LITERATURE CITED

Kriete, W. H., Jr. and J. G. Loesch. 1980. Design and relative efficiency of a bow-mounted pushnet for sampling juvenile pelagic fishes. Trans. Amer. Fish. Soc. 109:649-652.

Loesch, J. G. 1969. A study of the blueback herring, Alosa aestivalis (Mitchill), in Connecticut waters. Ph.D. Dissertation. University of Connecticut, Storrs, Connecticut, USA.

Loesch, J. G., and W. H. Kriete, Jr. 1980. Anadromous fisheries research program, Virginia. Annu. Rep. 1980. Nat. Mar. Fish. Serv. Proj. No. AFC 10-1. Virginia Institute of Marine Science, Gloucester Point, Virginia. 96 p.

Loesch, J. G., W. H. Kriete, Jr. and E. J. Foell. 1982. Effects of light intensity on the catchability of juvenile anadromous Alosa species. Trans. Amer. Fish. Soc. 111(1):41-44.

Loesch, J. G., W. H. Kriete, Jr., J. G. Travelstead, E. J. Foell and M. A. Hennigar. 1979. Biology and management of mid-Atlantic anadromous fishes under extended jurisdiction. Part II: Virginia Comp. Rep. 1977-1979. Nat. Mar. Fish. Ser. Proj. No. AFCS9-1 to 9-3. Virginia Institute of Marine Science, Gloucester Point, Virginia. 204 p.

Marcy, B. C., Jr. 1976. Early life history studies of American shad in the lower Connecticut River and the effects of the Connecticut

Yankee Plant. Pages 141-168 in D. Merriman and L. M. Thorpe (eds.), The Connecticut River Ecological Study; the Impact of a Nuclear Power Plant. Amer. Fish. Soc. Monogr. No. 1.

Ricker, N. E. 1975. Computations and interpretations of biological statistics of fish populations. Bull. Fish. Res. Bd. Can. No. 191. 382 p.

Whitney, R. R. 1961. The Susquehanna fishery study, 1957-1960. A report on the desirability and feasibility of passing fish at Conowingo Dam. Maryland Dept. Res. Educ., Contrib. No. 169. Solomons, Maryland. 81 p.

Table 3.1. Juvenile Alosa mean catch-per-unit-of-effort (CPUE) and the overall weighted mean ($\bar{x}$) in the James River, 1981.

Species	River Miles	CPUE			
		Jul 9	Aug 4	Aug 24	Sep 14
Alewife	(a)				
Blueback herring	75-80	(b)	(b)	0	1.2
	70-75	(b)	(b)	1.3	7.3
	65-70	12.6	5.2	4.8	1.5
	60-65	7.4	2.8	0.2	0.9
	55-60	5.3	0	0	0
	50-55	1.9	0	(b)	(b)
	$\bar{x}$	6.5	4.2	2.3	2.1
American shad	(a)				

(a) No alewife or American shad caught.
(b) Stratum not sampled.

Table 3.2. Juvenile Alosa mean catch-per-unit-of-effort (CPUE) and and the overall weighted mean ($\bar{x}$) in the Pamunkey River, 1981.

Species	River Miles	CPUE			
		Jul 7	Jul 27	Aug 17	Sep 9
Alewife	65-70	(a)	(a)	0	(a)
	60-65	13.5	2.1	0	0.2
	55-60	0	2.0	0	0
	50-55	3.8	2.5	1.2	0
	45-50	8.7	0.9	1.7	0.5
	$\bar{x}$	6.5	1.9	1.4	0.1
Blueback herring	65-70	(a)	(a)	8.4	(a)
	60-65	22.6	53.6	11.5	10.0
	55-60	1.4	7.6	0.2	4.0
	50-55	7.0	4.8	6.5	3.6
	45-50	11.6	0.9	31.4	0
	$\bar{x}$	10.6	16.7	11.6	5.8
American shad	65-70	(a)	(a)	4.1	(a)
	60-65	12.4	3.9	1.7	0.2
	55-60	3.4	3.7	0	0.2
	50-55	4.6	0	0.7	0
	45-50	1.0	0.5	0	0
	$\bar{x}$	5.3	2.0	1.6	0.2

(a) Stratum not sampled.

Table 3.3. Juvenile Alosa mean catch-per-unit-of-effort (CPUE) and the overall weighted mean ($\bar{x}$) in the Mattaponi River, 1981.

Species	River Miles	CPUE				
		Jul 6	Jul 30	Aug 10	Aug 25	Sep 10
Alewife	55-60	4.4	0.5	0.4	3.1	0
	50-55	1.5	1.0	0.7	1.4	0.7
	45-50	6.6	0	0.7	2.2	0.2
	40-45	27.5	(a)	0.4	0.3	0
	$\bar{x}$	10.0	0.7	0.6	1.9	0.4
Blueback herring	55-60	3.3	11.4	0.5	3.7	0
	50-55	1.0	12.2	0.4	0.2	0
	45-50	0.2	10.8	0.5	0	0
	40-45	0.5	(a)	0	0	0
	$\bar{x}$	1.3	11.6	0.5	2.0	
American shad	55-60	39.4	0	0	1.4	0
	50-55	9.6	0	0	4.1	0
	45-50	15.8	0	0.9	0.9	0
	40-45	7.1	0	0	0	0
	$\bar{x}$	18.0		0.9	2.2	

(a) Stratum not sampled.

Table 3.4. Juvenile Alosa mean catch-per-unit-of-effort (CPUE) and the overall weighted mean ($\bar{x}$) in the Rappahannock River, 1981.

Species	River Miles	CPUE			
		Jul 9	Aug 5	Aug 26	Sep 15
Alewife	75-80	46.3	3.3	2.4	1.2
	70-75	31.8	0.4	1.2	1.1
	65-70	15.1	2.0	1.6	0.2
	60-65	16.7	5.1	0.5	0.5
	$\bar{x}$	27.5	2.7	1.4	0.8
Blueback herring	75-80	122.9	156.3	120.2	362.4
	70-75	202.2	146.4	155.1	138.6
	65-70	219.6	112.0	38.2	10.3
	60-65	60.3	52.3	29.8	0.4
	$\bar{x}$	151.3	116.7	85.8	129.5
American shad	(a)				

(a) One American shad taken on August 26 between miles 70-75.

Table 3.5. Maximal CPUE for juvenile alewife in 1979, 1980 and 1981.

	1979	1980	1981
James	(a)	(a)	(b)
Chickahominy	(a)	(a)	+
Pamunkey	6.7	3.6	6.5
Mattaponi	6.0	2.9	10.0
Rappahannock	50.0	38.0	27.5
Potomac	3.5	2.0	+

(a) Data too few for a reliable estimate.
(b) No catch.
+ Not sampled.

Table 3.6. Maximal CPUE for juvenile American shad in 1979, 1980 and 1981.

	1979	1980	1981
James	(a)	(b)	(b)
Chickahominy	(a)	(b)	+
Pamunkey	57.4	7.1	5.3
Mattaponi	38.1	38.8	18.0
Rappahannock	(a)	(b)	(a)
Potomac	(b)	(b)	+

(a) Data too few for a reliable estimate.
(b) No catch.
+ Not sampled.

Table 3.7. Maximal CPUE for juvenile blueback herring in 1979, 1980 and 1981.

	1979	1980	1981
James	65.4	86.8	6.5
Chickahominy	365.2	154.5	+
Pamunkey	224.8	87.9	16.7
Mattaponi	73.0	4.6	11.7
Rappahannock	851.1*	715.7	151.3
Potomac	19.6	117.2	+

* Previously reported as 775.2; see text for explanation.
\+ Not sampled.

Table 3.8. Estimates of instantaneous daily mortality (M_d) for juvenile Alosa in 1979, 1980 and 1981.

Species	River	1979	1980	1981
Alewife	Mattaponi	0.036	0.033	0.105
	Pamunkey	0.040	0.041	0.058
	Rappahannock	0.033	0.023	0.082
American shad	Mattaponi	0.040	0.056	0.080
	Pamunkey	0.060	0.080	0.043
Blueback herring	James	0.048	a	0.016
	Chickahominy	0.067	0.090	b
	Mattaponi	0.034	0.022	c
	Pamunkey	0.040	0.031	0.016
	Rappahannock	0.046	0.035	0.009
	Potomac	0.034	0.042	b

a - No estimate of M_d made.
b - Not sampled.
c - M_d = 0.267; however, few fish captured ($\bar{x}$= 4.9 fish for the 30 July and 10 August sampling periods).

Figure 3.1. Growth Curves for Juvenile Alewives, 1981

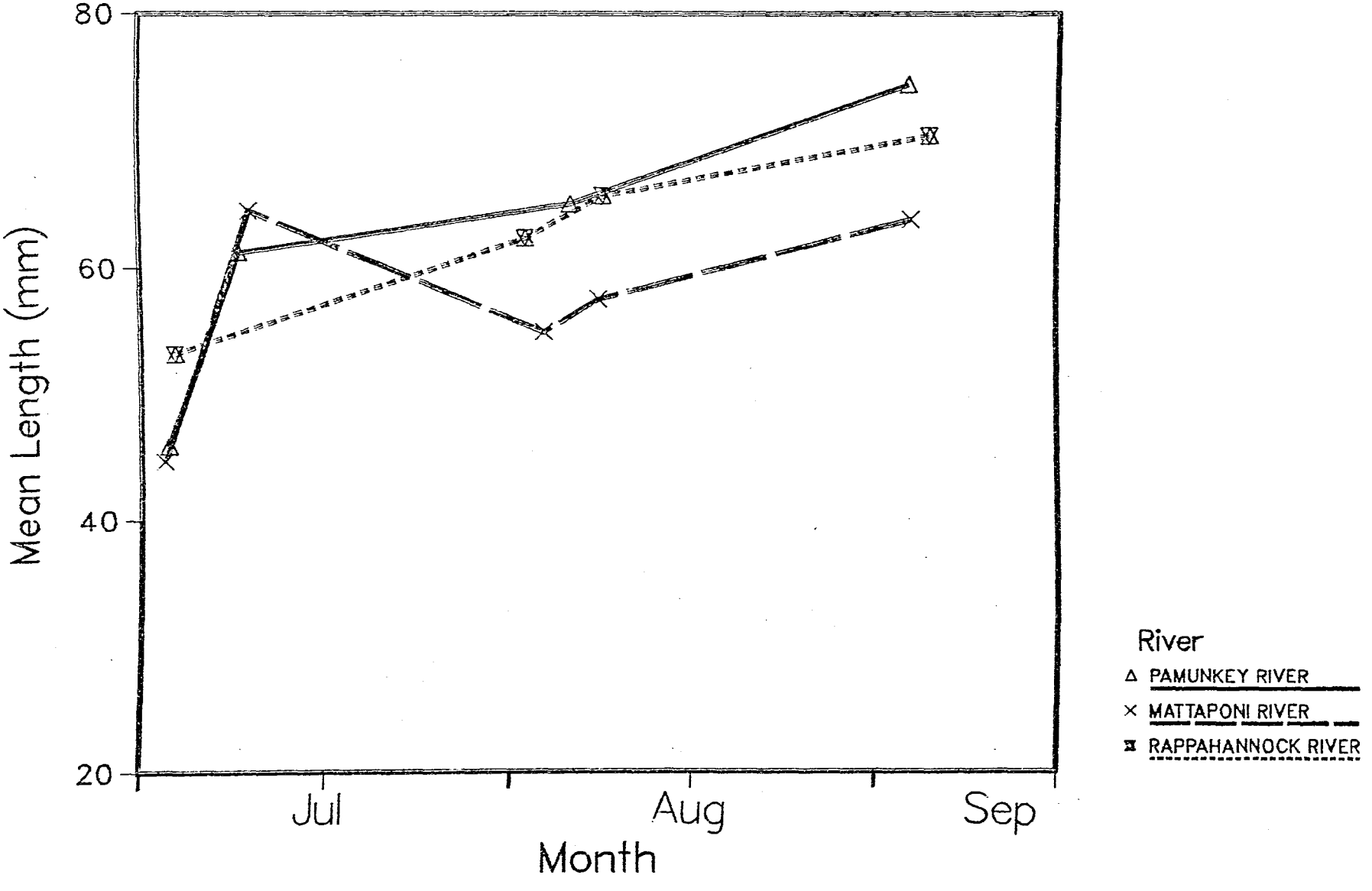


Figure 3.2. Growth Curves for Juvenile Blueback Herring, 1981

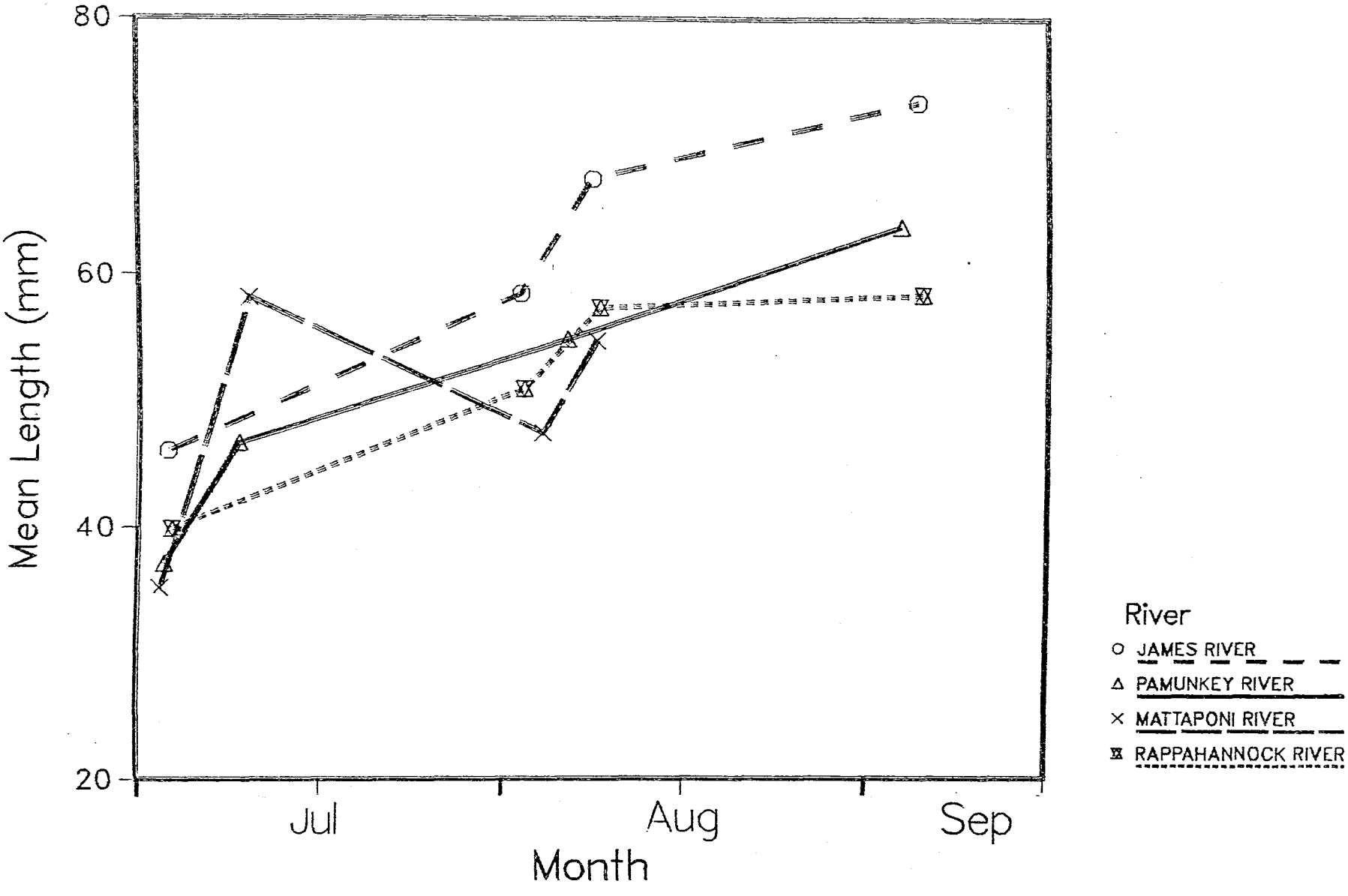


Figure 3.3. Growth Curves for Juvenile American Shad, 1981